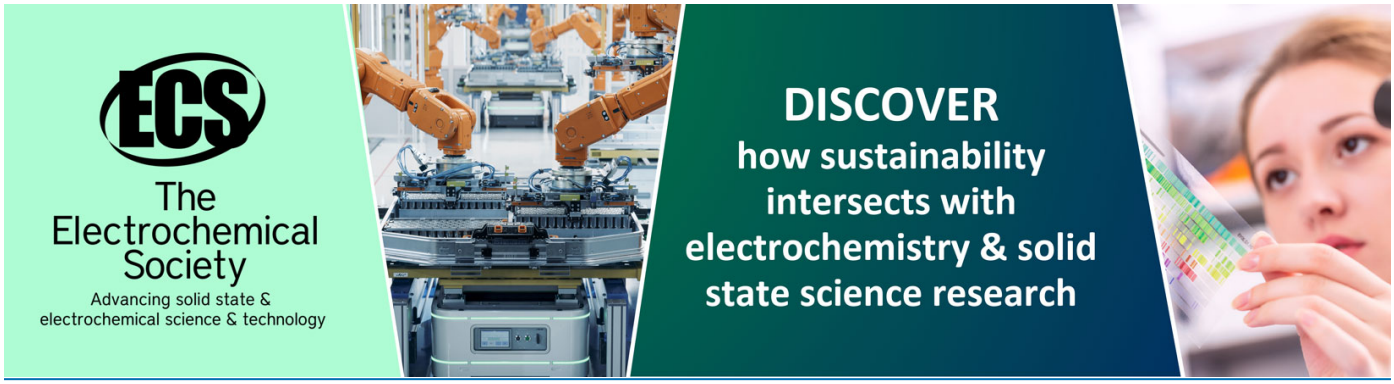
Shift focal spot X-ray tube to the imposition anode under long exposure



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Shift focal spot X-ray tube to the imposition anode under long exposure

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Abstract. X-ray non-destructive testing is an integral part of any modern industrial production. Microfocus X-ray sources make it possible to obtain projected images with an increased spatial resolution by using a direct geometric magnification during the survey. On the basis of the St. Petersburg State Electrotechnical University staff of the department of electronic devices and equipment has been designed model of microfocus X-ray computed tomography.

X-ray non-destructive testing is an integral part of any modern industrial production. One of the main trends in the development of X-ray defectoscopic complexes is the improvement of spatial resolution capabilities. Microfocus X-ray sources make it possible to obtain projected images with an increased spatial resolution by using a direct geometric magnification during the survey [1].

This distinctive feature of microfocus X-ray machines can be used to obtain tomographic images. This gives rise to the development of a separate field of technology – microfocus X-ray tomography or microtomography [2].

The large value of the magnification factor in the microfocus tomography imposes serious demands on the accuracy of positioning of all elements of the tomographic system. The main factors affecting the quality of tomographic image restoration:

1. The angle of inclination of the rotation axis of the object to the vertical axis of the radiation receiver;
2. Accuracy of measuring the distance from the source to the X-ray receiver;
3. Shift of the X-ray source coordinate relative to the line connecting the axis of rotation and the geometric center of the radiation receiver.

The low accuracy of positioning the listed elements leads to the formation of various kinds of "artifacts" on the image being reconstructed and can cause distortion of small parts and defects of the objects under study.

On the basis of the St. Petersburg State Electrotechnical University staff of the department of electronic devices and equipment has been designed model of microfocus X-ray computed tomography (figure 1). Monoblock microfocus apparatus based on the sealed X-ray tube BS-16 was used as an X-ray source (figure 2). The main technical characteristics of the tube used are shown in table 1.

The small size of the focal spot is achieved by using a double focusing system of the electron beam. This makes it possible to obtain X-ray images with geometric magnification up to 200 times. The effective size of the voxel of tomographic images reaches 1 μm.

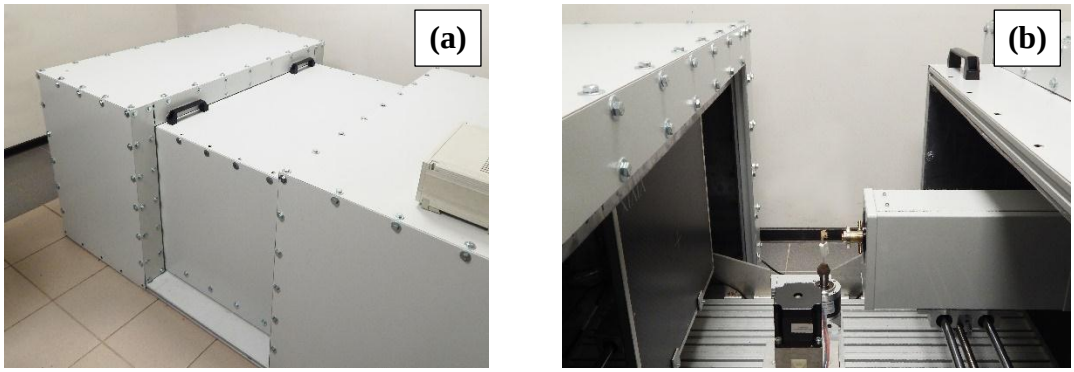

Figure 1. Microfocus X-ray computer tomograph MRKT-01: **(a)** – appearance; **(b)** – source and receiver of radiation with a displacement system.

Table 1. Technical specifications.

Anode voltage, kV	40–150
Anode current, mA	0.01–0.2
Maximum power in continuous mode, W	7
Focal spot size, μm	<5
Mode of operation	continuous, re-short-term
Anode performance type	impaired
Dimensions (L×W×H), mm	315×76×76
Current of heat, A	3.9

Figure 2. X-ray tube of the closed type BS-16.

The X-ray apparatus works continuously for a long time. For example, it takes more than 26 min of continuous operation for a set of 800 projections and an exposure time of 2 s for each projection. Various specific effects begin to appear in similar modes of operation of the X-ray tube. One such effect is the displacement of the focal spot over the surface of anode. Such a shift does not have a significant effect on the resulting images in single images at small magnification ratios. The effect becomes significant when typing projection data for a tomography with a large magnification. This leads to a dynamic disruption of the positioning accuracy of the elements of the tomographic system.

The endings of two metal needles 0.7 mm in diameter were taken to study the characteristic dimensions of the focal spot displacement. The needles were located close to each other. The direct geometric increase was 200 times (figure 3). The survey was carried out at an accelerating voltage of 115 kV and an anode current of 20 μA. In all, 200 shots were taken with an exposure of 1 s for each

shot. The coordinates of the point of each needle were determined on the obtained images and the deviation from the original position was recorded. The calculation of the deviation of the focal spot was made taking into account the magnification factor and the pixel dimensions of the radiation receiver. The results of the calculations are shown in figure 4.

The results of the studies indicate the presence of a direct pattern of the magnitude and direction of the focal spot drift. Two ways to compensate for the drift of the focal spot are proposed based on the experiments performed:

1. Use of an electromagnetic deflection system mounted on the anode of an X-ray tube;
2. Digital displacement of the image after its registration, taking into account the position of the reference points in the original picture.

Further research will continue in the direction of a quantitative analysis of the effect of the effect examined on the reconstruction of a tomographic image.

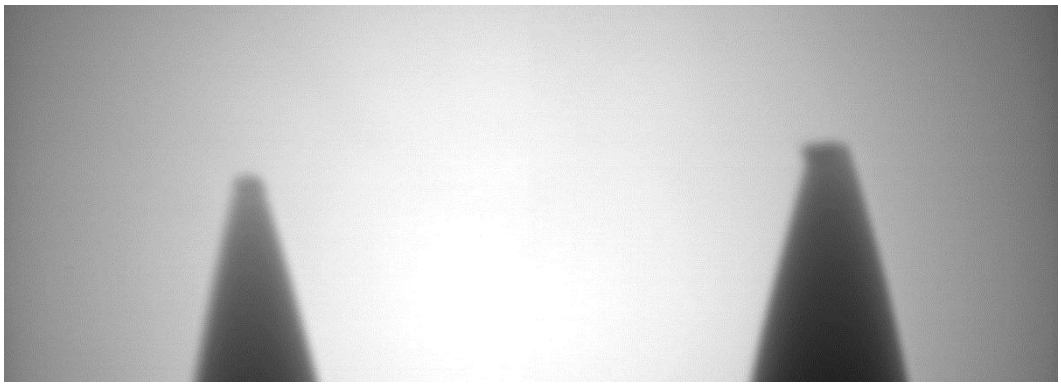

Figure 3. X-ray image of two needles.

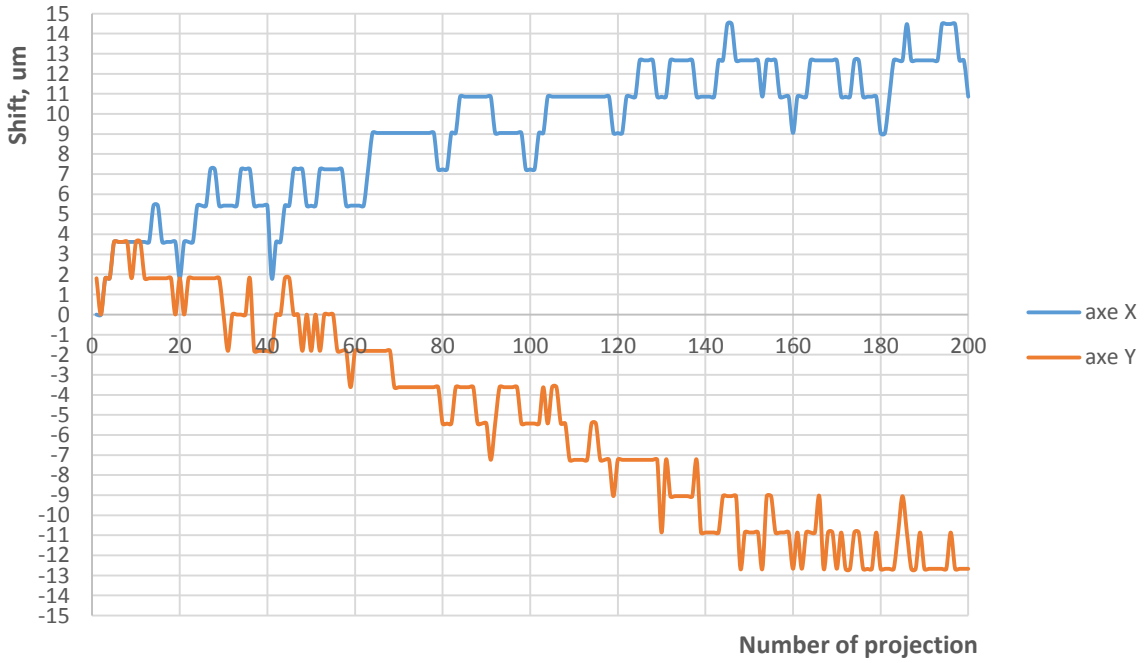

Figure 4. Dependence of the amount of displacement of the focal spot on the projection number.

Acknowledgments

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References

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